

6th Technical Committee Meeting

EC4 GHG Study

Providence, Rhode Island

Department of Environmental Management

Room 300

Background: Phased Approach



Summary of October 5th Meeting

1. Attempted to find an initial 80% pathway using Phase I options
2. Phase I options did not quite achieve 80% (~74% of 1990 emissions in 2050)
3. Started discussing further Phase 1 options to achieve 80%, emphasis on non-energy sector (land-use/land-use change/forestry [LULUCF], waste, etc.)

Phase 1 Measures: Reminder

1. **Energy efficiency** (after RISEP BAU ends, annual newly-added savings reach 3.5% of 2009 sales (electricity/gas) and 1.0% of 2009 sales (distillate heating oil))
2. **Vehicle-Mile-Traveled Reductions** (~15% of passenger car/truck VMT by 2050)
3. **Zero-Carbon Grid** (~97% of generation carbon-free by 2050)
4. **Distributed Renewables** (~30% distributed solar generation)
5. **Clean Imports** (two new 1090 MW interconnections with Québec)
6. **Nuclear Relicensing** (Millstone 2+3 are not retired)

Phase 1 Measures: Reminder (*continued*)

- 7. Advanced Electric Heating** (air-source and ground-source heat pumps meet over 80% of residential/commercial heating load by 2050)
- 8. Biomass/Biofuel Heating** (20% biodiesel in residential/commercial heating oil, 1% heating met by biomass by 2050)
- 9. Electric Transport** (up to 80% VMT delivered by BEV/PHEV by 2050, mode-dependent)
- 10. Transport Biofuels** (31% biodiesel in diesel, 78% cellulosic ethanol in gasoline by 2050)
- 11. Aviation Efficiency (40% reduction in fuel consumption by 2050)*
- 12. No Further Forest Loss (no net loss of forest or cropland after 2011)*

Progress since October 5th Technical Committee Meeting

- Completed cost assumption inputs for all* Phase 1 measures
- Kigali Amendment to Montreal Protocol: non-energy emissions from ozone-depleting substitutes reduced in baseline
- Revisions to land-use, land-use change and forestry projection
 - Replaced EPA data with 2003/2011 RIGIS datasets, providing better description of forest/other land cover
 - RIGIS data are then extrapolated back to estimate 1990 LULUCF emissions
- Solid waste emissions disappear after closure of Central Landfill

Reconstructing 1990 GHG Inventory

In order to ensure that the 1990 GHG inventory emissions and our *projected* emissions are comparable, we revisited the 1990 inventory calculation. In particular:

- 1990 inventory omits LULUCF
- 1990 inventory calculates electricity consumption emissions differently

$$13.76 \text{ MT} - 0.29 \text{ MT} - 0.99 \text{ MT} = 12.48 \text{ MT}$$

Recalculating Resilient Rhode Island Targets

Emissions Target, below 1990	Year	Allowed Emissions (MT CO ₂ e/year)
10%	2020	11.32
45%	2035	6.87
80%	2050	2.50

Phase 2 Base Narratives

Phase 2a: “80% below 1990”

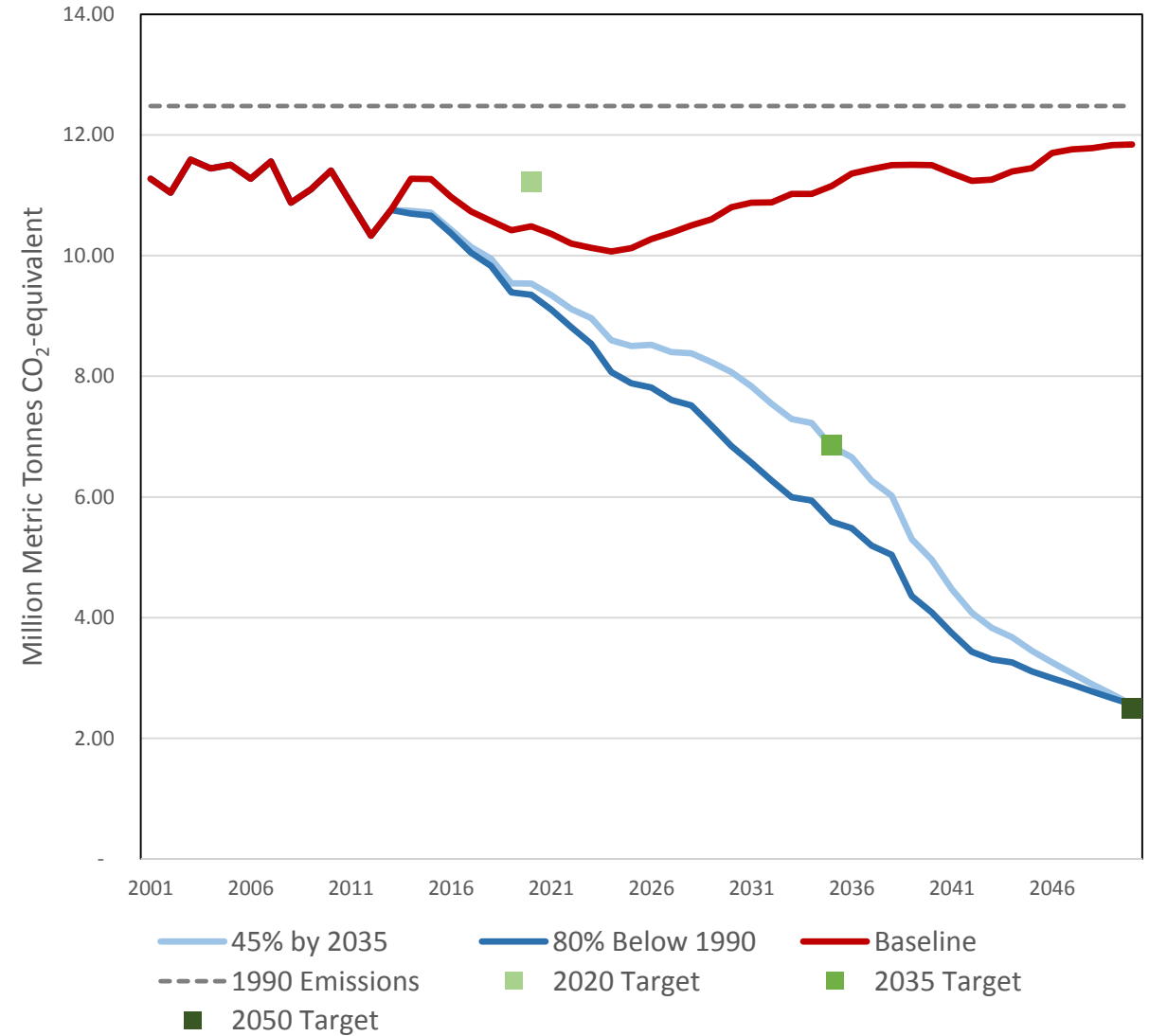
- All Phase 1 measures except distributed renewables, heating biofuels
- Maximal implementation of phase 1 measures (“Phase 1 limit”)

Phase 2e: “45% by 2035, 80% by 2050”

- Reduced biodiesel blend, ethanol blend, and cellulosic ethanol (in ethanol) blend through 2035
- Heat pumps and electric vehicle shares 74% of Phase 1 limit in 2035
- New renewable additions only 70% of Phase 1 limit through 2035

Phase 2a/2e Emissions

- Even the baseline scenario exceeds 10%-by-2020 target
- Phase 2a and 2e have the same annual emissions by 2050, but different cumulative emissions
- But – scenario 2e needs to ramp down faster after 2035

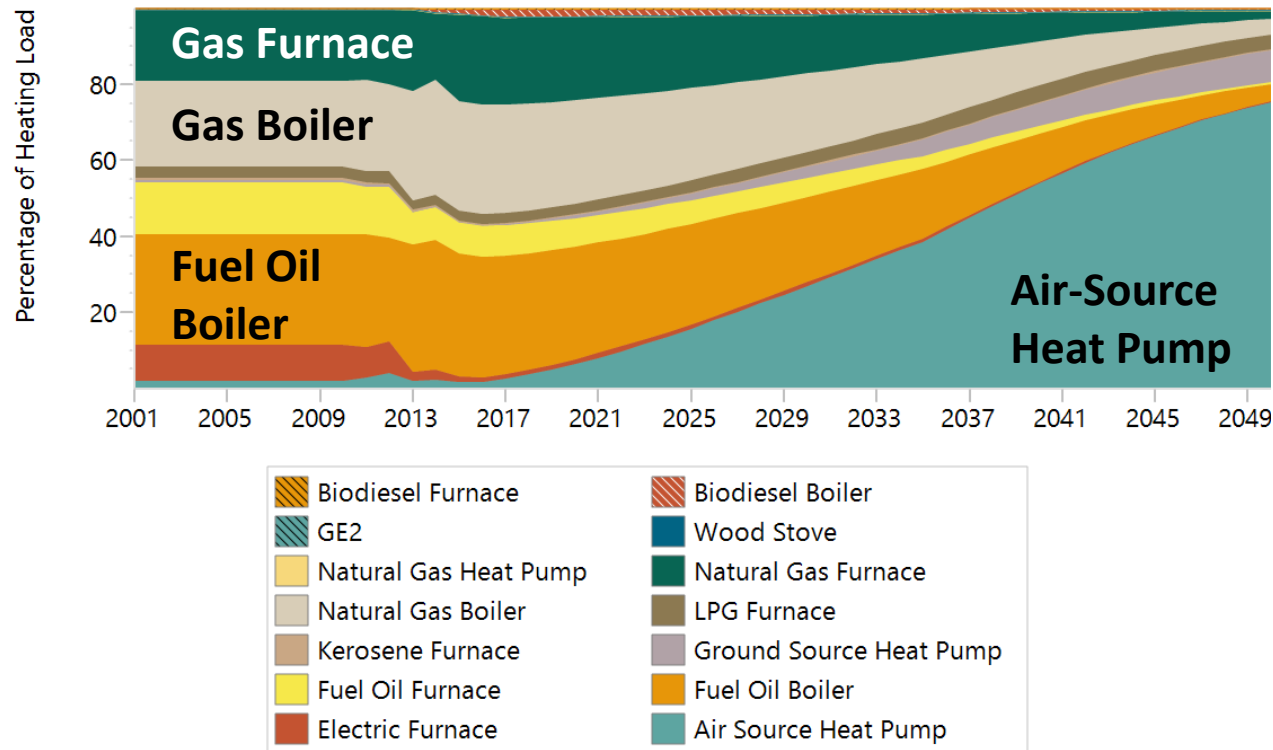


Phase 2a/2e Comparison

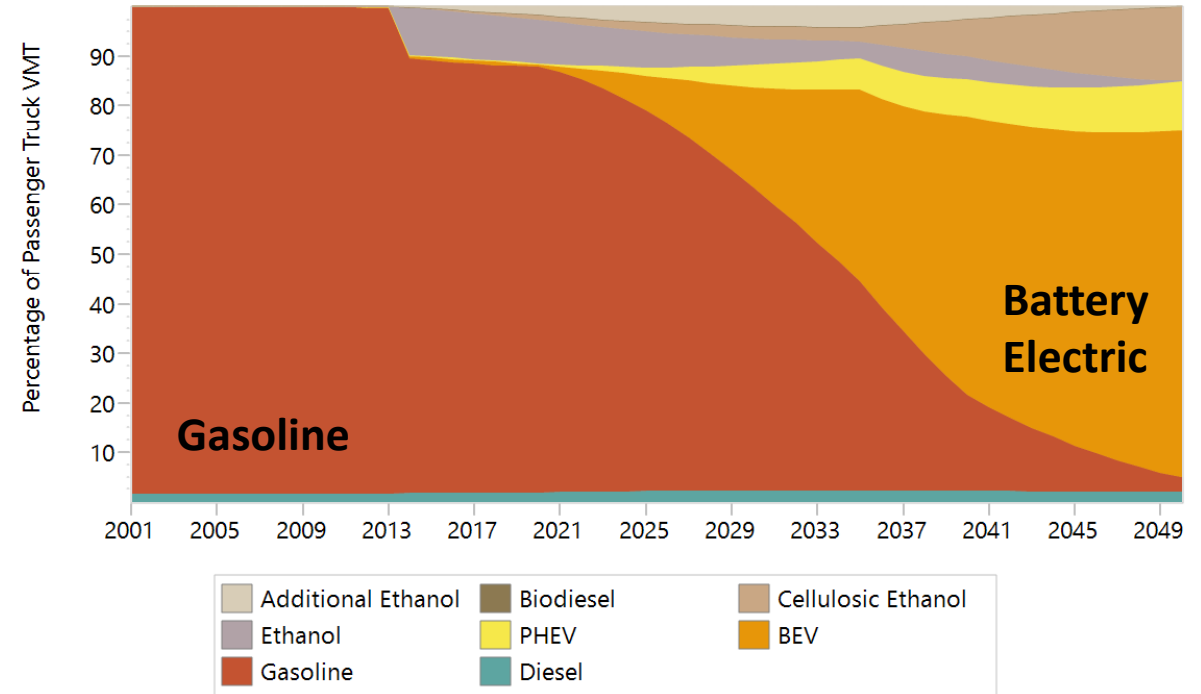
- The model we've built is not a full stock-turnover analysis – it relies on:
 - Shares of vehicle-miles-travelled (transport sector)
 - Shares of space heating load (residential/commercial sectors)
- Nevertheless we can calculate sales/retirement impacts *ex post facto*, and we know:
 - a) Phase 2a already requires early retirements of fossil fuel heating technologies and vehicles
 - b) Phase 2e will require further retirements

Sample Implementation Rates for 45%/2035, 80%/2050

Heating Load Shares, Single-Family Households

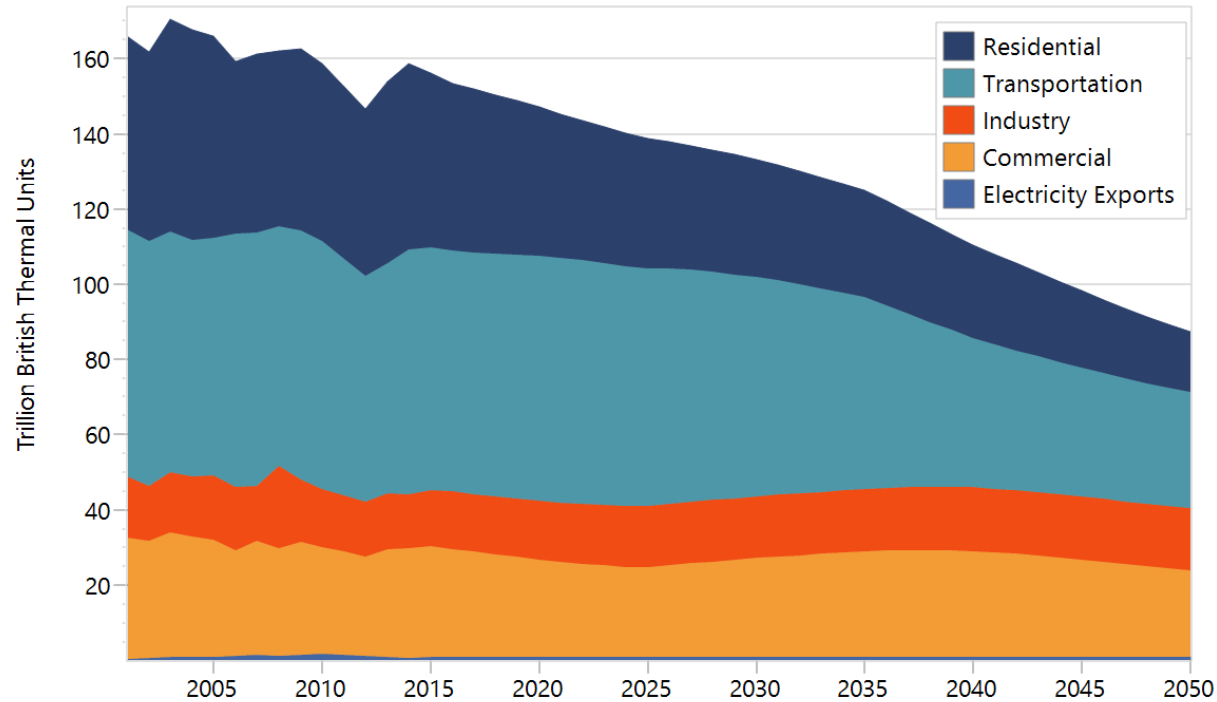


VMT Shares, Passenger Trucks

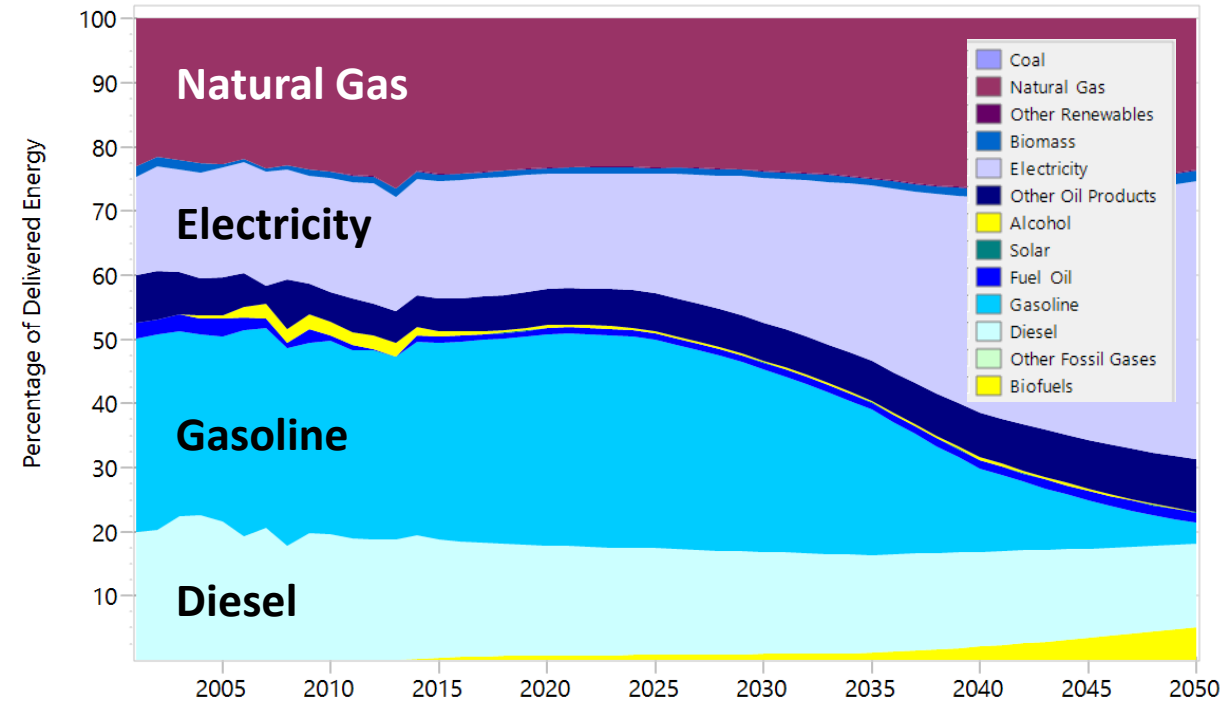


Additional Results for 45%/2035, 80%/2050: Energy Demand

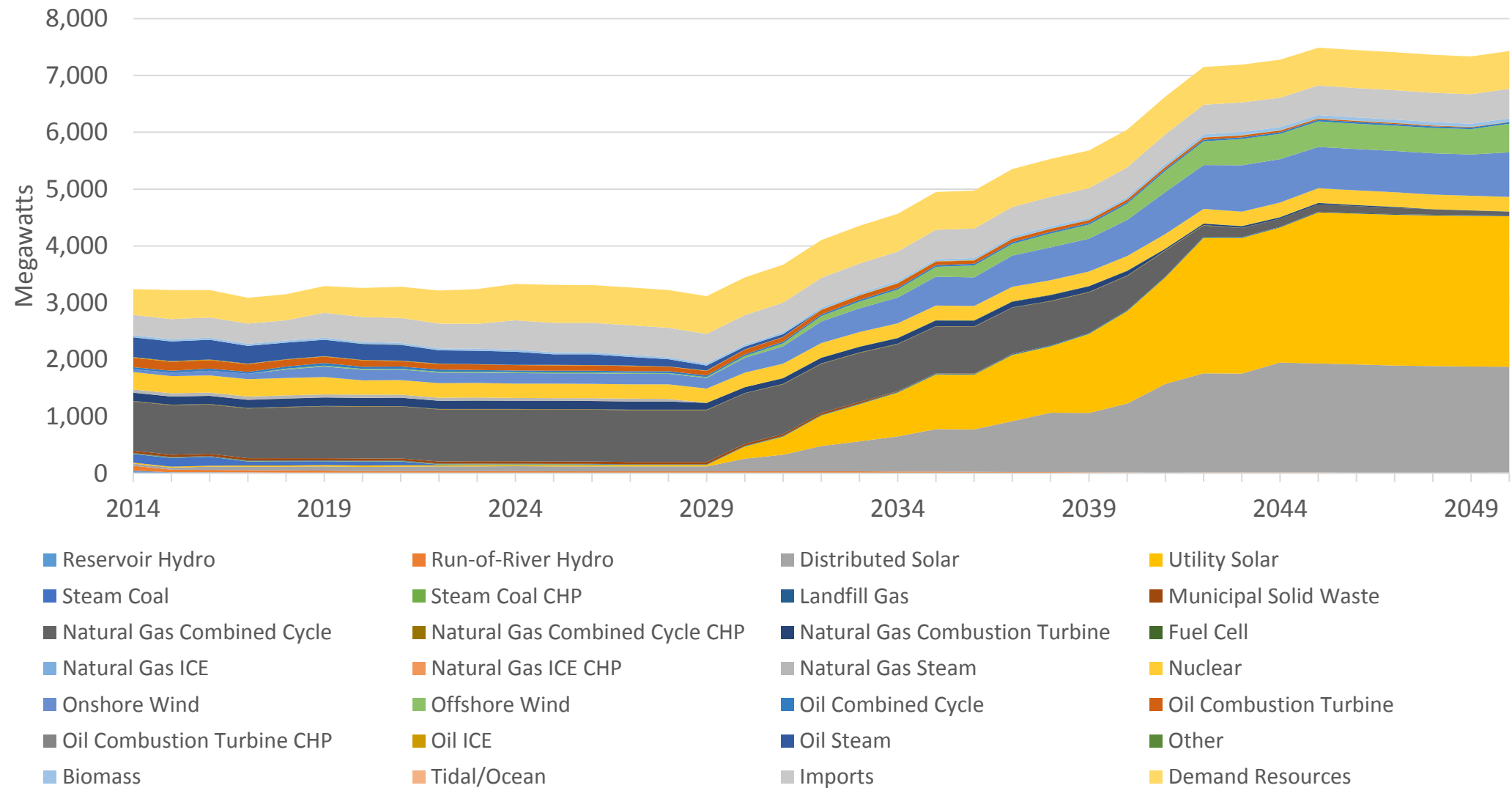
Total End-Use Demand



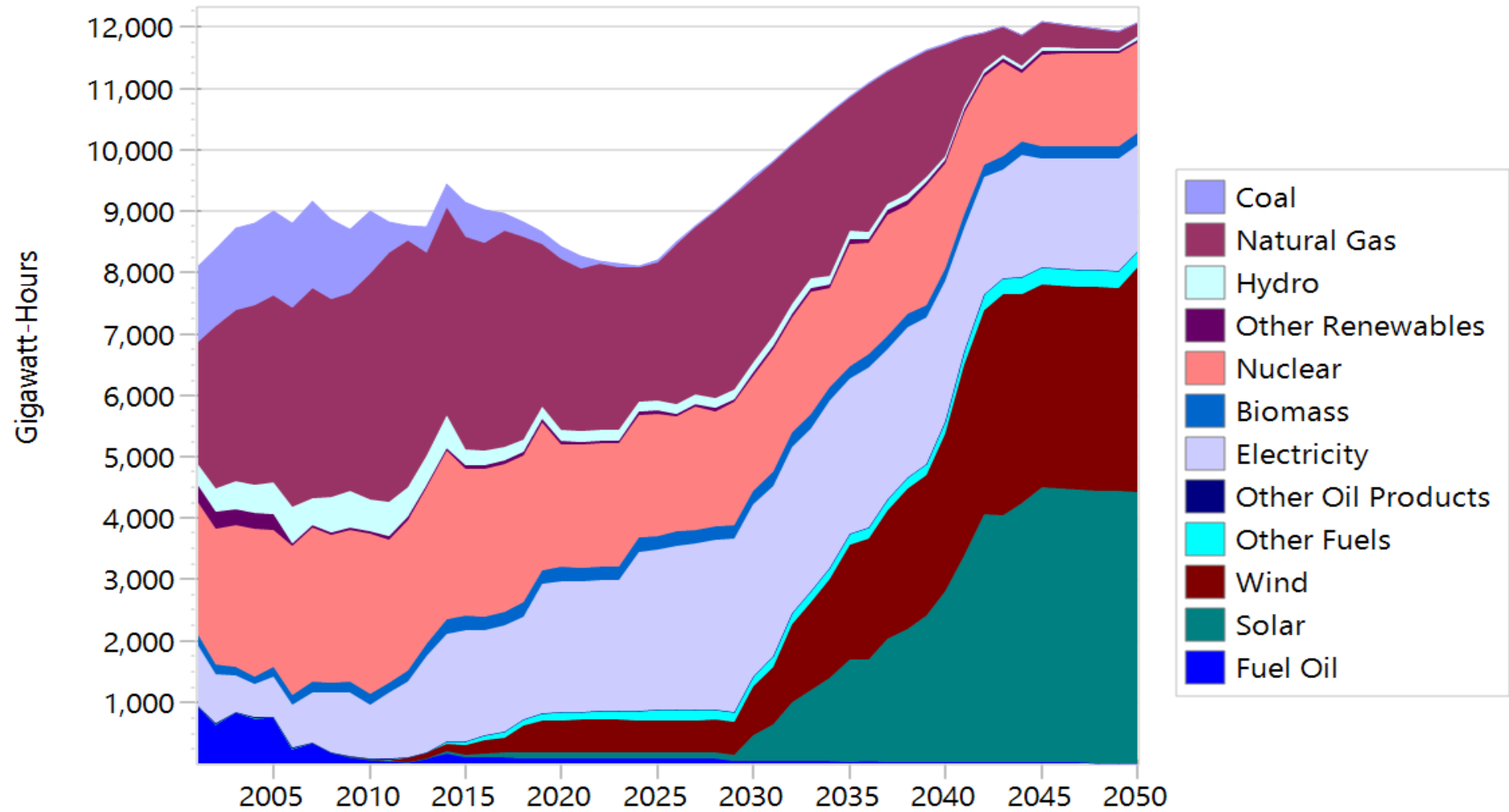
Fuel Shares in End-Use Demand



Additional Results for 45%/2035, 80%/2050: Electricity Capacity



Additional Results for 45%/2035, 80%/2050: Electricity Generation



Phase 2 Variant Narratives

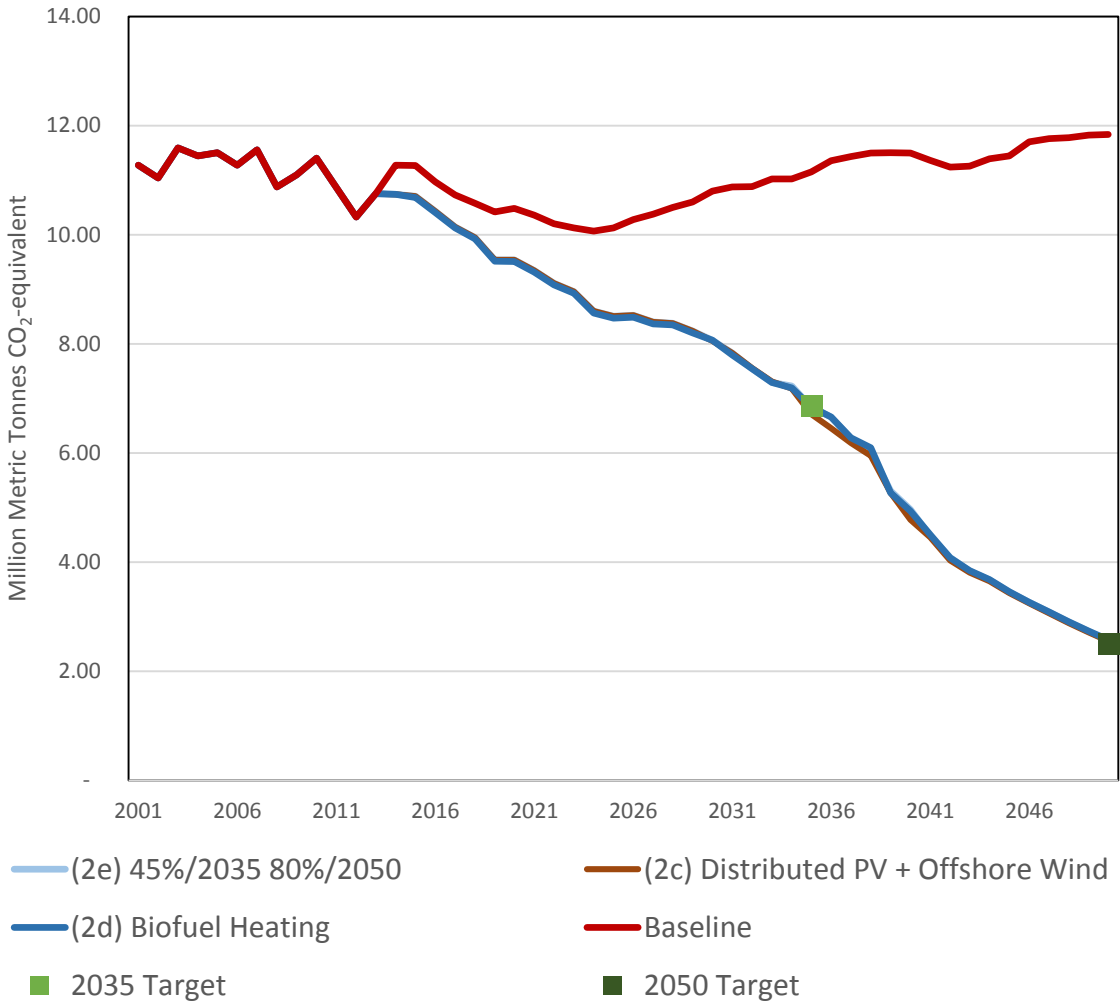
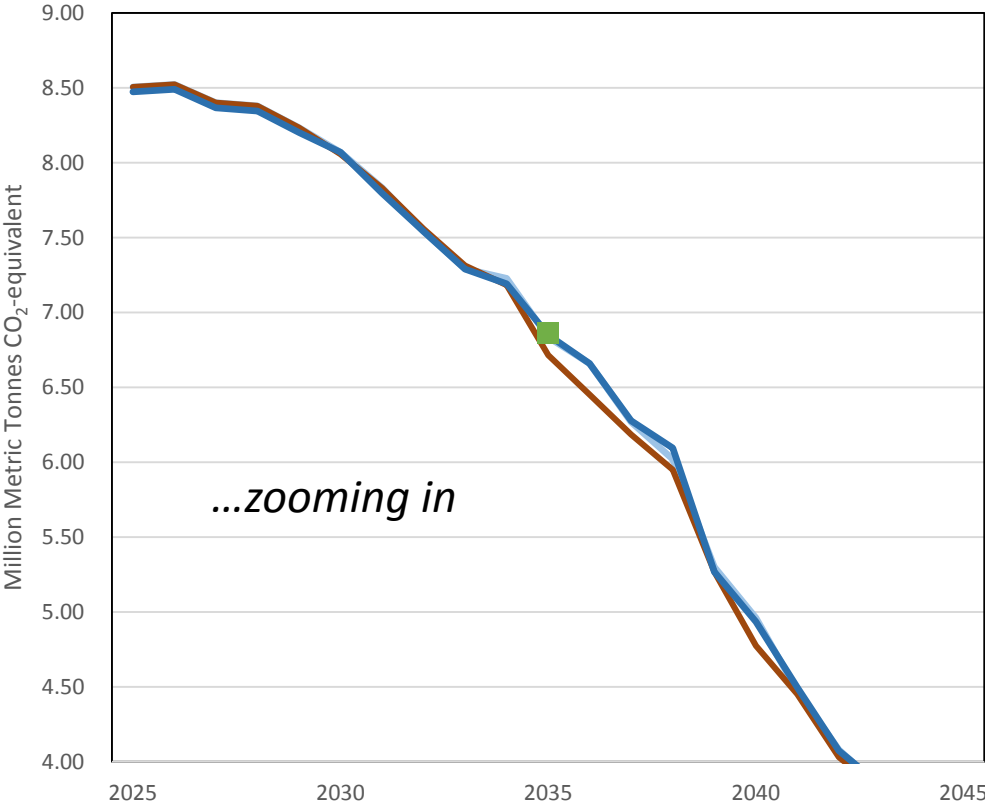
Phase 2c: “Distributed PV and Offshore Wind” (variant of 2e)

- Some onshore wind traded for offshore
- Some utility-scale PV additions traded for distributed PV

Phase 2d: “Biofuel Heating” (variant of 2e)

- Includes Phase 1 measure “Biomass/Biofuel Heating”
- Heat pump implementation reduced to 85% of Phase 1 limit

Phase 2e/2c/2d Emissions



Abatement Cost Calculations

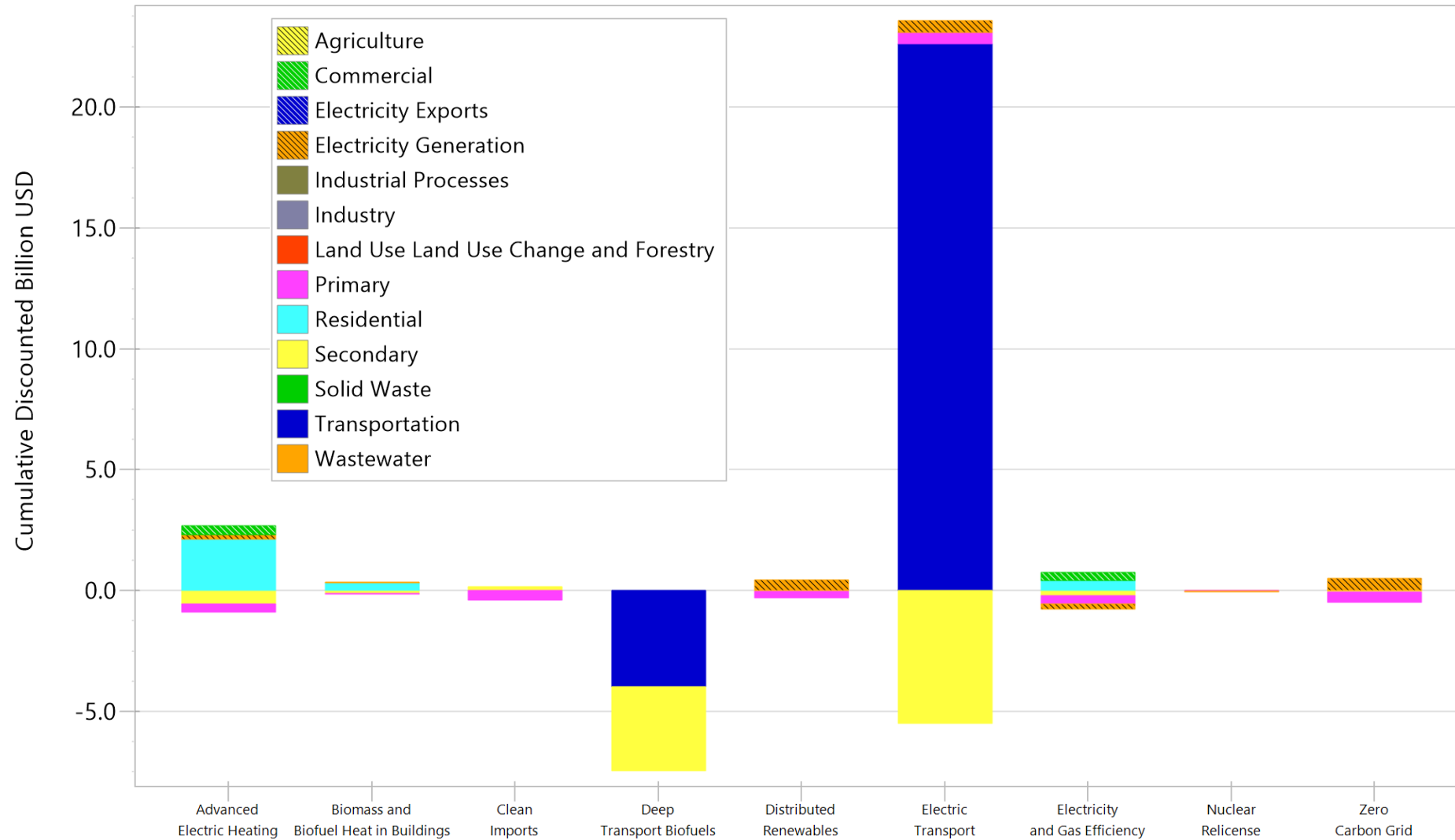
- Different cost categories tracked separately:
 - Demand (may include capital, O&M, implementation)
 - Electric sector capital, fixed/variable O&M
 - Fuel costs
 - Other miscellaneous costs
- Costs may be discounted (model default 7%)
- Abatement cost calculated internally as:

$$\frac{\text{cumulative, discounted cost vs. baseline}}{\text{cumulative GHG savings vs. baseline}}$$

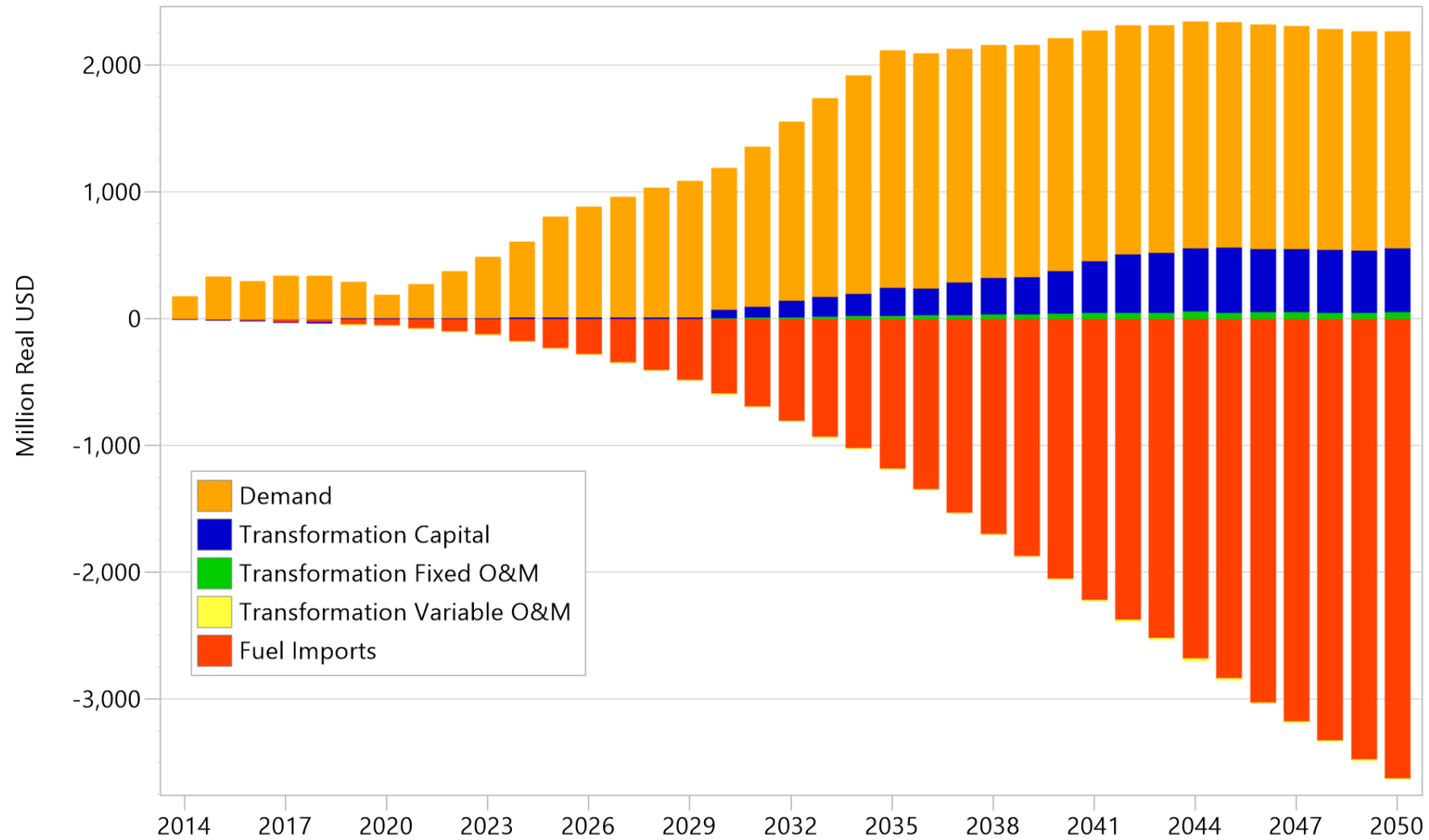
Excluded Costs

- Costs for VMT reduction strategies impossible to pin down – excluded from analysis
- Costs for grid storage of electricity in high-renewable scenarios unreliable – excluded from analysis
- No costs provided for aviation efficiency (which could happen anyways), reduced forest loss measures

2050 Discounted Costs, Phase 1 Measures



Phase 2e Real Costs for 45%/2035, 80%/2050



Cost Comparison Among Phase 2 Variants

- Net Present Value (i.e. cumulative discounted cost vs. baseline) may be broken down by sector
- Can then calculate average cost per tonne of CO₂e abated

Cost relative to Baseline	80% Below 1990 (Phase 2a)	45%/2035 80%/2050 (Phase 2e)	Distributed PV/Offshore Wind (Phase 2c)	Biofuel Heating (Phase 2d)
Demand	16.6	9.9	9.9	9.8
Residential	2.5	2.3	2.3	2.3
Transportation	13.4	6.9	6.9	6.9
Industry	-	-	-	-
Commercial	0.7	0.7	0.7	0.7
Electricity Exports	-	-	-	-
Transformation	1.3	1.1	1.4	1.0
Transmission and Distribution	-	-	-	-
Electricity Generation	1.3	1.1	1.4	1.0
Resources	-8.9	-7.0	-7.0	-6.9
Production	-0.0	-0.0	-0.0	-0.0
Imports	-8.9	-7.0	-7.0	-6.9
Exports	-	-	-	-
Unmet Requirements	-	-	-	-
Environmental Externalities	-	-	-	-
Non Energy Sector Costs	-	-	-	-
Net Present Value (Billion 2013 USD)	9.0	4.0	4.3	4.0
GHG Savings (MT CO₂e)	172.0	149.9	150.8	150.2
Cost of Avoiding GHGs (2013 USD/Tonne CO₂e)	52.3	26.8	28.2	26.3